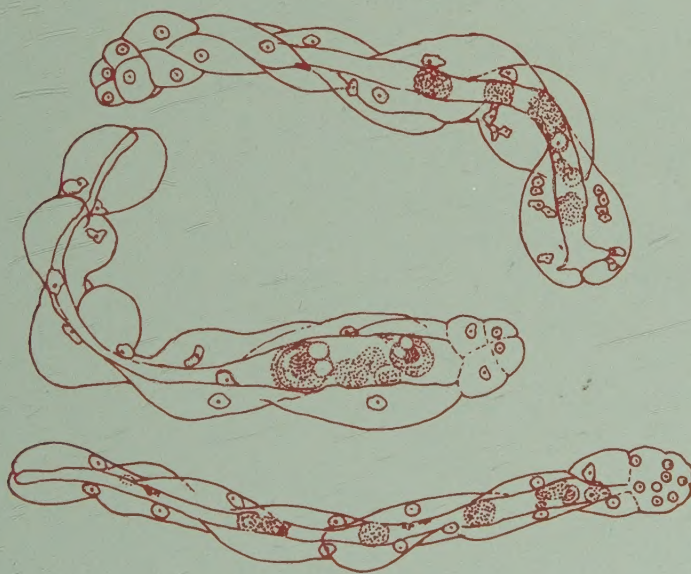


NOAA Technical Report NMFS 100

February 1991

Marine Flora and Fauna of the Eastern United States Dicyemida

Robert B. Short



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Dicyemida

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Marine Flora and Fauna of the Eastern United States

Dicyemida

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ABSTRACT

This manual treats the six species of dicyemid mesozoans that have been reported in three species of hosts (*Octopus vulgaris*, *O. joubini*, and *O. briareus*) from the eastern coast of North America and the Gulf of Mexico, including the Florida Keys. All are parasites of species of *Octopus* and are in the genus *Dicyema*, family Dicyemidae. In the introduction, the life cycle, as known, and the general morphology of dicyemids are briefly described, and methods are given for collecting and preparing material for study. These are followed by a key to species and by an annotated checklist, which includes data, some hitherto unpublished, on their known prevalence in hosts from various localities including Bimini and Bermuda.

Introduction

The dicyemid mesozoans are a relatively small group of minute parasites with a simple yet multicellular structure. They parasitize cephalopod molluscs and are found primarily in the fluid-filled renal sacs (renal coelom) or "kidneys." In decapod cephalopods (squids, sepiolids, and teuthoids), they have been found also in the reno-pancreatic coelom and occasionally in the pericardium (Hochberg 1983). Dicyemids were discovered by Cavolini (1787) and were described by Krohn (1839) and Erdl (1843).

The name Mesozoa was proposed by van Beneden (1876) to indicate his belief that the simple structure of these parasites represents an evolutionary stage between the protozoans and metazoans. There has been considerable controversy regarding their taxonomic position. The dicyemids have usually been considered to form, together with the orthonectids (parasites of various invertebrates), the phylum Mesozoa (e.g., Hyman 1940). Stunkard (1954), however, has argued that the mesozoans should be included as a class in the phylum Platyhelminthes. Furthermore, because of differences between the dicyemids and orthonectids in internal structure and the lack of homologies in their life-cycle stages, other workers (e.g., Kozloff 1969; Hochberg 1983) have considered them not to be closely related. Hochberg (1983) suggested that "it is best to treat these two assemblages as separate phyla [Dicyemida and Orthonectida] and to use the term 'Mesozoa' to refer to their grade of organization only." In the present manual

this systematic scheme will be followed, and only members of the phylum Dicyemida will be considered.

Recent accounts of the dicyemids have been published by Hochberg (1982, 1983, 1990) and Stunkard (1982). Earlier reviews include those of Hyman (1940), Stunkard (1954), Czihak (1958), Grassé (1961), and McConnaughey (1963, 1968).

A total of about 40 species of cephalopods, representing 15 genera, are currently known to be hosts of dicyemids. The parasites occur mostly in cuttlefishes, sepiolids, and octopods and less frequently in loliginid squids and have been reported from temperate, polar, and subtropical waters in many parts of the world.

This manual deals with the dicyemid mesozoans reported from off the coast of eastern North America and the Gulf of Mexico, including the Florida Keys. All hosts reported herein are species in the genus *Octopus*.

Morphology and Life Cycle

In the renal sacs, vermiform stages are the conspicuous ones. These occur with the anterior ends adhering to, and more or less embedded in, the renal appendages (venous appendages) of the host, with most of the body floating freely in the host urine within the sac. They may also be seen swimming slowly in the urine, propelled by their cilia. Vermiform stages have a simple multicellular structure (Figs. 1, 2). A single elongated axial cell (except in stem

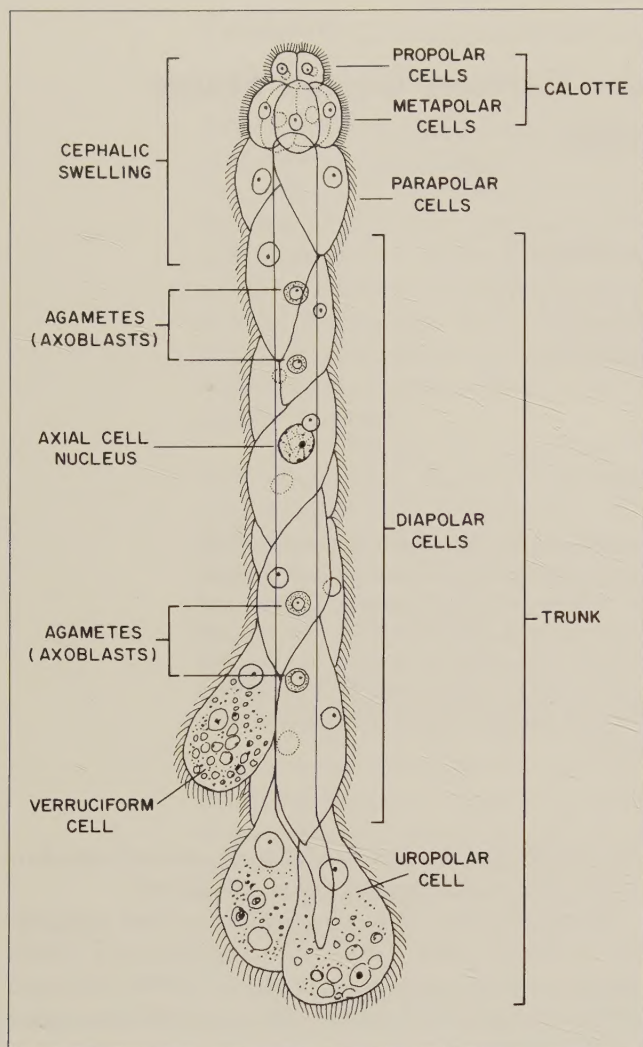


Figure 1

Generalized drawing of a young dicyemid (*Dicyemeneae*) showing terms for various parts. Modified slightly from McConnaughey (1951).

nematogens, which may have two or three axial cells; see below) is surrounded by a single layer of ciliated peripheral (somatic) cells. Somatic cells are arranged in groups. The anterior or "head" group is modified into a calotte consisting (typically) of two tiers of cells, the propolar and metapolar cells. These cells have shorter, denser cilia than other somatic cells. Immediately behind the calotte are the parapolar cells (usually two), then trunk cells, consisting of several diapolars, and two posterior uropolar cells covering the posterior end of the axial cell. Parapolar and trunk cells often contain refractive granular material in their cytoplasm (see Figs. 3, 20). The diapolar and uropolar cells of certain species become so laden with such material that they are swollen; if this is the case, they are termed verruciform cells (Fig. 1).

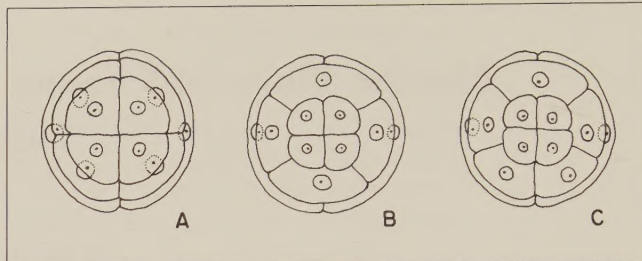


Figure 2

Diagrams of anterior end views of primary and secondary nematogens and rhombogens of the genera *Dicyema* (A), *Pseudicyema* (B), and *Dicyemeneae* (C). Calotte patterns and parapolar cells shown. Redrawn from Nouvel (1947). Cilia not drawn.

Figure 3 (Facing page, top)

Photographs. (A) *Dicyema typoides* rhombogens. (B) *D. hypercephalum* rhombogens. (C) *D. apalachiensis* nematogens. In part from Short (1962, 1964). Scale in micrometers.

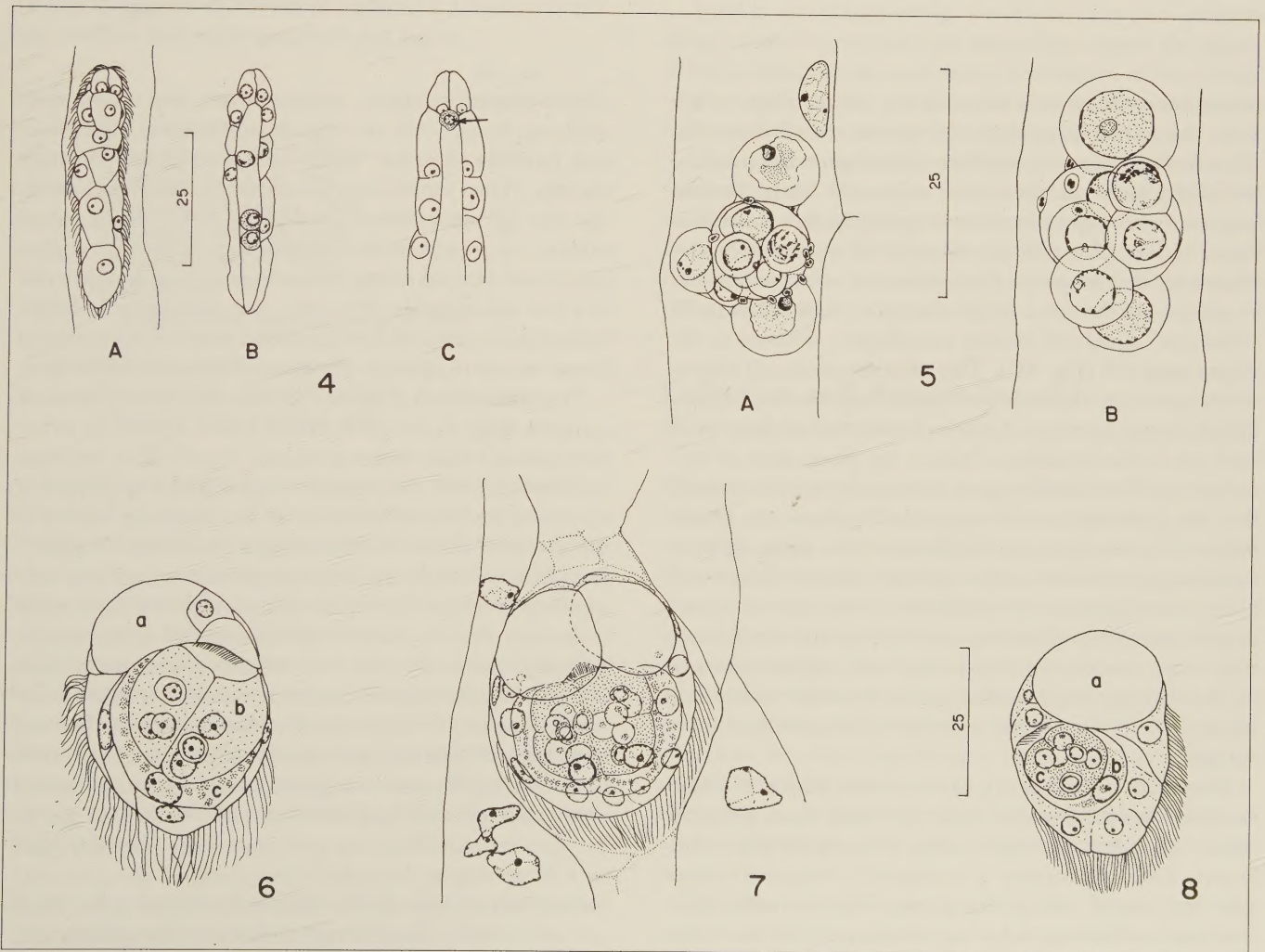
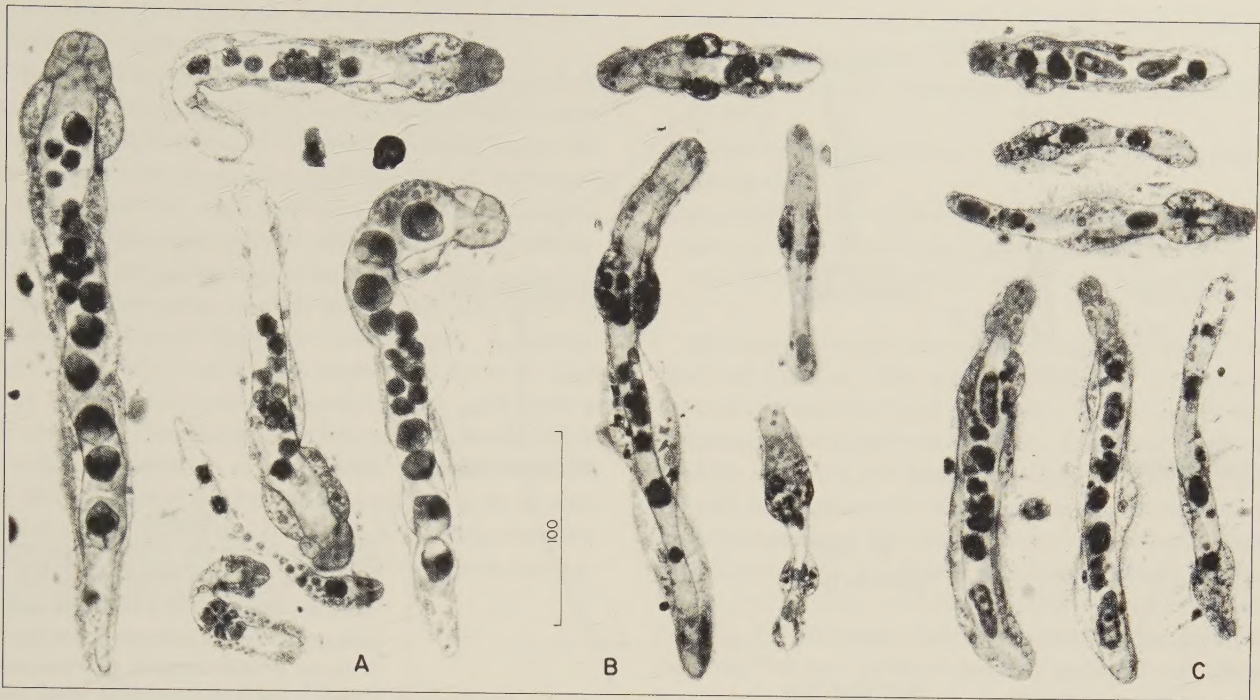
Figures 4-8 (Facing page, bottom)

Fig. 4. Vermiform embryos of *D. bilobum*. (A) Surface view. (B) Optical section. (C) Optical section of anterior end of *Dicyemeneae eledones*, showing anterior abortive axial cell (arrow). (A and B) redrawn from Couch and Short (1964); (C) modified from Nouvel (1947). **Fig. 5.** Infusorigens within axial cells of rhombogens. (A) *Dicyema briarei*. (B) *D. aegira*. (A) redrawn from Short (1961); (B) redrawn from Short and Damian (1967). **Figs. 6-8.** Infusoriform larvae. (6) *Dicyema aegira*, optical sagittal section (to same scale as Fig. 5). (7 and 8) *Dicyema briarei*. (7) Dorsal view within axial cell of rhombogen. (8) Optical sagittal section. a = refringent body; b = capsule cell; c = urn cell. (6) modified from Short and Damian (1966). (7 and 8) from Short (1961). Scales in micrometers. Cilia not shown.

The number and arrangement of somatic cells is rather constant for a species but may vary within narrow limits. Somatic cell numbers range among species from 14 to 40. Lengths of adult vermiform stages vary from about 260 to 10,000 μm , depending on the species.

Typical mature vermiform stages encountered are of two types or phases: nematogens and rhombogens. Besides a nucleus, the axial cells of nematogens contain within their cytoplasm agametes (axoblasts), which are asexual reproductive cells, and vermiform embryos (Figs. 3C, 4) in various stages of development. Axial cells of young nematogens may contain only agametes (as in Fig. 1). Axial cells of rhombogens contain one or more of a bisexually reproductive stage (or gonad), the infusorigen (Fig. 5), and also infusoriform larvae (Figs. 3A, 6-8), which are ciliated when fully developed. A diagram of the life cycle is shown in Figure 9.

Vermiform embryos develop within axial cells of nematogens from mitotic division of agametes. Early in development, they attain the definitive somatic cell number; they



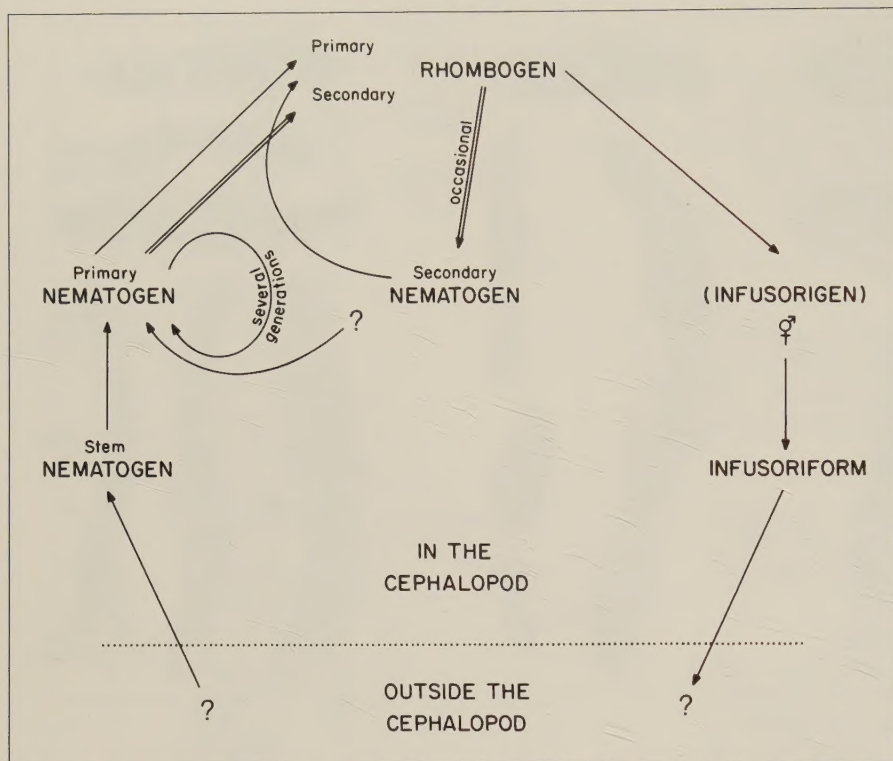


Figure 9

Diagram of the life cycle. Single straight line from primary NEMATOGEN indicates development of vermiform embryos into primary rhombogens; double lines indicate transformation of recognizable nematogens into secondary rhombogens and of rhombogens into secondary nematogens. From McConnaughey (1951).

then continue to grow in size and, at a certain stage, escape from the parent nematogen (a process called eclosion). They further mature to become nematogens and produce vermiform embryos within their axial cells. By this means, large numbers of primary nematogens populate the cephalopod kidney. Vermiform embryos of some species of dicyemids (in the genus *Dicyemene*) at eclosion possess, in addition to the usual single elongated axial cell, a small "abortive" axial cell located immediately anterior to the larger axial cell (Fig. 4C). This abortive axial cell degenerates soon after the embryo escapes from the nematogen. When a large number of primary nematogens have been built up in the cephalopod kidney by production of vermiform embryos, a change in the population occurs such that the predominant mature phase becomes the rhombogen. Rhombogens may originate in two ways: 1) from immature vermiform stages (primary rhombogens) and 2) by transformation of functional nematogens to rhombogens (secondary rhombogens). During this transformation, some transitional stages may have large numbers of single cells (agametes?) in their axial cells; other transitional stages may contain both vermiform embryos and infusorigens.

The infusorigen (Fig. 5), as mentioned above, is a hermaphroditic individual or stage (probably more properly called a gonad) that remains within the axial cell of a rhombogen. Each infusorigen is composed of a more or less spherical "axial" cell, with male reproductive cells inside and female cells more or less surrounding it. The male cells

consist of spermatogonia, spermatocytes, and tailless spermatozoa; female cells are oogonia and oocytes. Spermatozoa, formed within the "axial" cell, emerge and penetrate oocytes. When fertilization is completed, the zygote develops into an infusoriform larva (Figs. 6-8), which, when mature, escapes from the rhombogen and from the cephalopod host with the urine. Rhombogens typically have one to a few infusorigens (Fig. 3A), and sometimes in larger individuals a series of developmental stages of infusoriform larvae extend in opposite directions from each infusorigen.

The infusoriform (Figs. 6-8) is morphologically the most complex stage in the cycle and is rather similar in structure among a wide variety of species. It is ovoid or pyriform and has cilia over the posterior region and a large part of the dorsal and lateral surfaces. A characteristic feature is the presence of two relatively large "refringent bodies," each located within an anterodorsal apical cell and surrounded by a thin layer of this cell's cytoplasm. Refringent bodies are often crystalline. In some species of dicyemids, however, the bodies are not refractive and are termed mucoid; in other species bodies are absent or at least not readily apparent. In the interior of infusoriforms are two large capsule cells that form the so-called urn. These cells often contain conspicuous granules and appear in lateral view relatively thin and more or less C-shaped (Figs. 6, 8); they surround four urn cells posteriorly, dorsally, and to a large degree laterally. Cytoplasm of the urn cells usually stains more darkly than that of other cells. Each urn cell usually contains two nuclei and one smaller cell

interpreted as a germinal cell. Two germinal cells per urn cell have been reported in a few species.

As indicated by Figure 9, the life cycle of dicyemids is not completely known. That part within the host is pretty well understood, but little or nothing is known about the mode of entry into new hosts and initiation of infection. The earliest known stage seen in young cephalopods is termed the stem nematogen. It differs from other nematogens chiefly in having two or three axial cells instead of one. Stem nematogens, at first very small, may grow to be considerably larger than other nematogens. Agametes in their axial cells develop into vermiform embryos that emerge and become primary nematogens, each with a single axial cell. Presumably, the infusoriform larva, which leaves the cephalopod, is responsible for infecting new hosts, but whether it infects a cephalopod directly or uses an intermediate host is not clear, nor is it known whether infection occurs by means of the entire larva or by only certain cells (germinal cells?).

Dicyemid Families and Genera

To date 68 species of dicyemids have been described in the two families and eight genera listed below.

	No. of species
Family Dicyemidae	
<i>Dicyema</i> von K��lliker, 1849	33
<i>Pseudicyema</i> Nouvel, 1933	1
<i>Dicyemennea</i> Whitman, 1883	26
<i>Dicyemodoca</i> Wheeler, 1897	1
<i>Pleodicyema</i> Nouvel, 1961	1
<i>Dodecadicyema</i>	
Kalavati and Narasimhamurti, 1980	1
Family Conocyemidae	
<i>Conocyema</i> van Beneden, 1882	4
<i>Microcyema</i> van Beneden, 1882	1

Members of the family Conocyemidae differ from those of the family Dicyemidae in one major way: peripheral cells of adult vermiform stages lose their cilia and fuse to form a syncytium covering the axial cell, whereas in the Dicyemidae peripheral cells of adult vermiform stages retain their cilia and their individual identity.

Genera in the Dicyemidae have been determined usually by the number and arrangement of cells in the calottes of the primary and secondary nematogens and rhombogens. The situation in the Conocyemidae is not clear, and the systematics of this group needs revision. The calottes of genera in the family Dicyemidae have the following configurations:

Dicyema: 8 polar cells (4 propolar, 4 metapolar), polar and metapolar cells opposite each other (Fig. 2A).

Pseudicyema: same as *Dicyema* except that polar cells alternate with metapolar cells (Fig. 2B).

Dicyemennea: 9 polar cells (4 propolar, 5 metapolar) (Figs. 1, 2C).

Dicyemodoca and *Pleodicyema*: 10 polar cells (4 propolar, 6 metapolar).

Dodecadicyema: 9 to 14 polar cells (4 propolar, 6 metapolar, plus, in most individuals, 3 (occasionally 2) much smaller cells forming the anterior tip of the calotte).

An important species character is the peripheral (somatic) cell number. This can be determined accurately for vermiform embryos and generally for young or small nematogens because each cell has a single nucleus, which is easily visible. Care should be taken, however, in determining cell numbers for rhombogens (and sometimes also large nematogens) because in certain species (e.g., *Dicyema aegira*) peripheral trunk cells sometimes contain accessory nuclei, i.e., nuclei in addition to the original cell nucleus (see Fig. 15). Accessory nuclei apparently arise by mitotic budding that may produce daughter nuclei of very unequal size (McConnaughey 1951), and their presence may cause difficulty in obtaining reliable cell counts.

Species are characterized also by the size and general shape of adult vermiform and infusoriform stages, the shape of the calotte, the anterior extent and degree of branching of the axial cell, the presence or absence of verruciform cells, and the structure of the infusoriform larva.

Only species in the genus *Dicyema* have been reported from the coast of eastern North American and the Gulf of Mexico, and in this genus abortive axial cells have not been reported nor has branching of the axial cell. As mentioned above, the genus *Dicyema* is characterized by 4 propolar and 4 metapolar cells.

Collection and Preparation of Dicyemids for Study

The following procedure is used commonly for preparation of dicyemids. The octopod host, if active, can be anesthetized by addition of 70% ethanol to sea water. It then is laid on its back and a midventral cut of the mantle is made from its anterior edge posteriorly to expose the conspicuous, fluid-filled renal sacs, which lie at the surface of the visceral mass. The renal sacs are semitransparent, and within them lie the renal appendages (see Fig. 39), which are outpocketings of the venae cavae. Vermiform dicyemids adhere to the renal appendages, often with their calottes embedded in depressions in the renal epithelium. Smaller vermiform individuals occur within the folds and crevices of the appendages, and a few dicyemids may also occur free in the urine.

The renal sacs are cut open and the appendages removed, *en masse* or a piece at a time, with the attached

dicyemids. Octopods, especially more mature ones, often harbor heavy dicyemid infections, and the vermiform stages can be seen easily with the lower powers of a dissecting microscope appearing as "hairs" projecting from the edges of the renal appendages. Occasionally light infections occur and are more difficult to detect. Smears with pieces of renal appendage are made on coverslips or slides

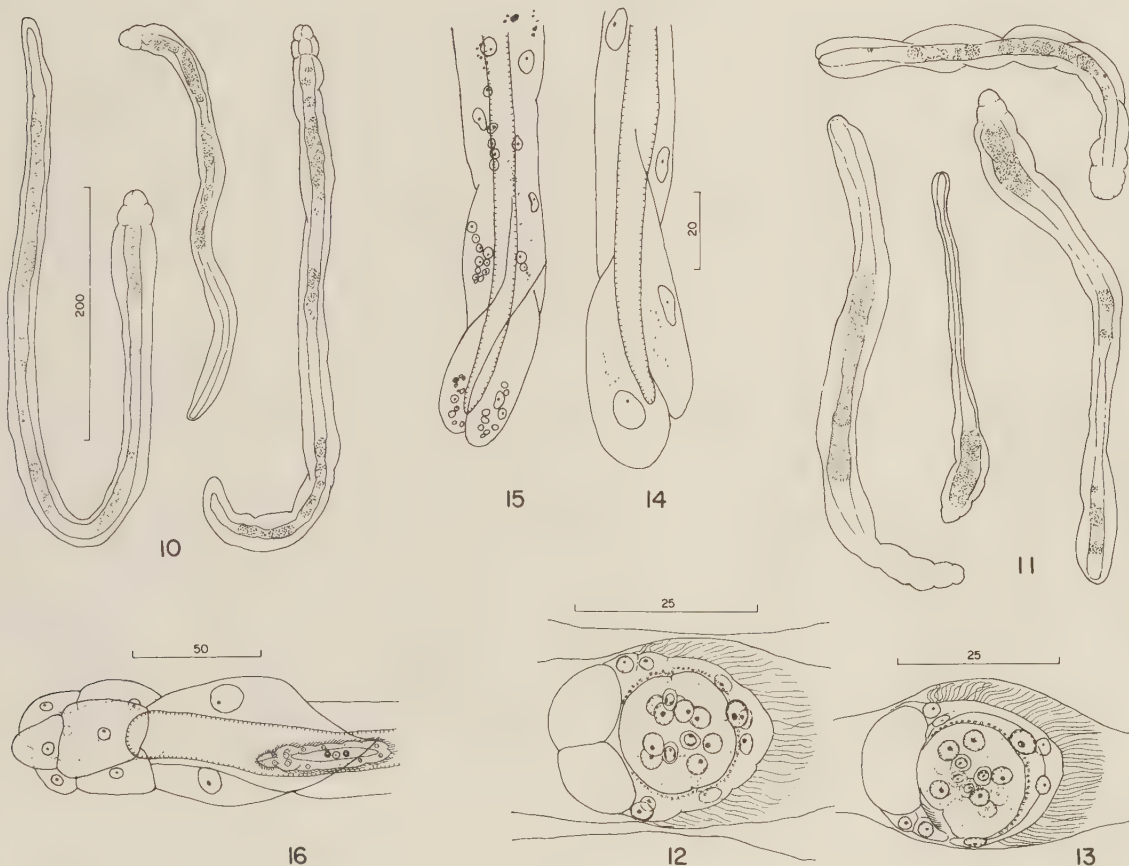
and, when fixed, stained, and mounted, are useful for study. Bouin's fixative is satisfactory and can be followed by staining with hematoxylin (e.g., Ehrlich's acid hematoxylin or Heidenhain's iron hematoxylin) and, if desired, by counterstaining with eosin. Care should be taken not to let the coverslip smears become dry at any time during the process from fixative to mounting medium.

Key to the Dicyemid Mesozoa of the East Coast of North America and the Gulf of Mexico

Genus *Dicyema* von K  lliker, 1849

- 1 Somatic cells of vermiform stages most often 22, varying from 20 to 25 (very seldom 18 and 19) 2
- 1 Somatic cells fewer than 20 3
- 2(1) Adult vermiform stages usually 400 to 1500 μm in length; somatic cell number 22, seldom 21 to 25; tendency for infusorigens and their products to be located well forward in axial cell of rhombogens causing a swelling behind the calotte (cephalic swelling); somatic cells not conspicuously charged with granules, a pronounced tendency to produce accessory nuclei in the posterior diapolar and uropolar cells. Vermiform embryos 40 to 50 μm at eclosion. Refrangent bodies, in infusoriforms viewed laterally, appearing smaller than the cluster of 4 urn cells (see Figs. 5B, 6) *Dicyema aegira* (Figs. 10-16)

Hosts: *Octopus vulgaris* Cuvier, 1797; *Octopus joubini* Robson, 1929

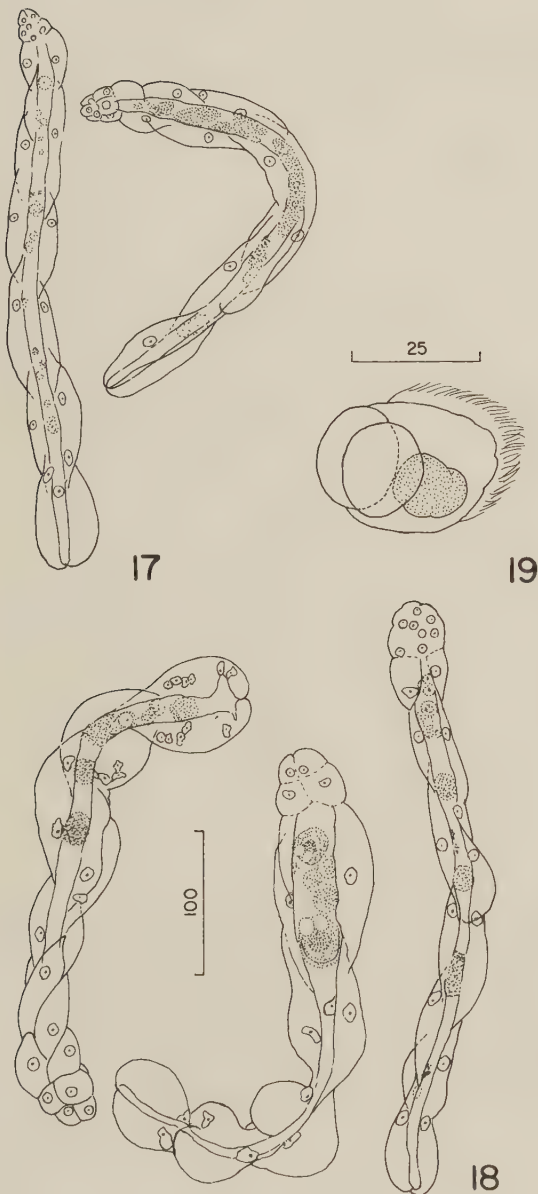


Figures 10-16

Dicyema aegira. (10) Nematogens, mature, showing general shape. (11) Rhombogens, mature showing general shape. (12 and 13) Infusoriform larvae, frontal view (12), sagittal optical section (13). (14) Posterior portion of trunk of young nematogen. (15) Posterior portion of trunk of rhombogen showing fragmentation of nuclei in somatic cells. (16) Anterior end of large nematogen showing calotte and its relation to the axial cell, which contains a vermiform embryo. (14-16) redrawn from McConnaughey and Kritzler (1952). Scales in micrometers. Cilia not shown on mature vermiform stages.

- 2(1) Adult nematogens from about 300 to slightly over 1000 μm in length; largest adult rhombogens about 1000 μm , often smaller; somatic cell number usually 20 to 22, most often 22, seldom 18, 19, 23, 24; body usually about the same width throughout with no conspicuous cephalic swelling; cytoplasm of somatic cells, especially uropolar and posterior diapolar, characteristically charged with particulate matter variously appearing as fine granules or small globules of spherical, oval, or irregular shape (Fig. 20); granular material usually denser and more conspicuous in rhombogens than in nematogens, with tendency toward formation of verruciform cells. Vermiform embryos about 60 to 70 μm at eclosion. Refrinent bodies, in infusoriforms viewed laterally, appearing larger than the cluster of 4 urn cells (see Figs. 5A, 7, 8). . . *Dicyema briarei* (Figs. 17-20)

Host: *Octopus briareus* Robson, 1929



Figures 17-19

Dicyema briarei. (17) Nematogens (to same scale as Fig. 18). (18) Rhombogens. (19) Infusoriform larva, side view, showing refringent bodies and urn cells (stippled). (17-19) redrawn from Short (1961). Cilia not shown on vermiform stages.

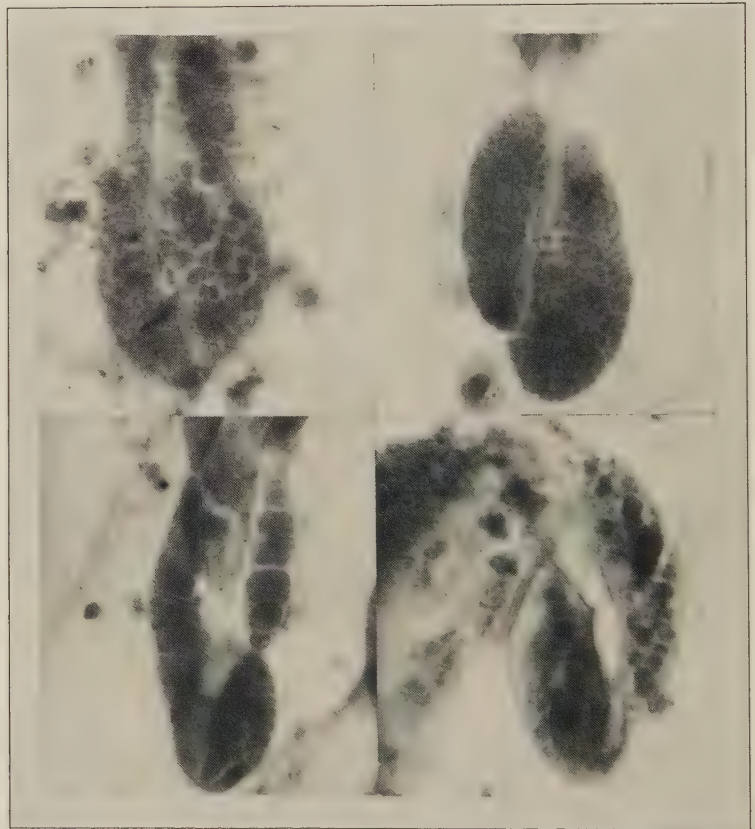
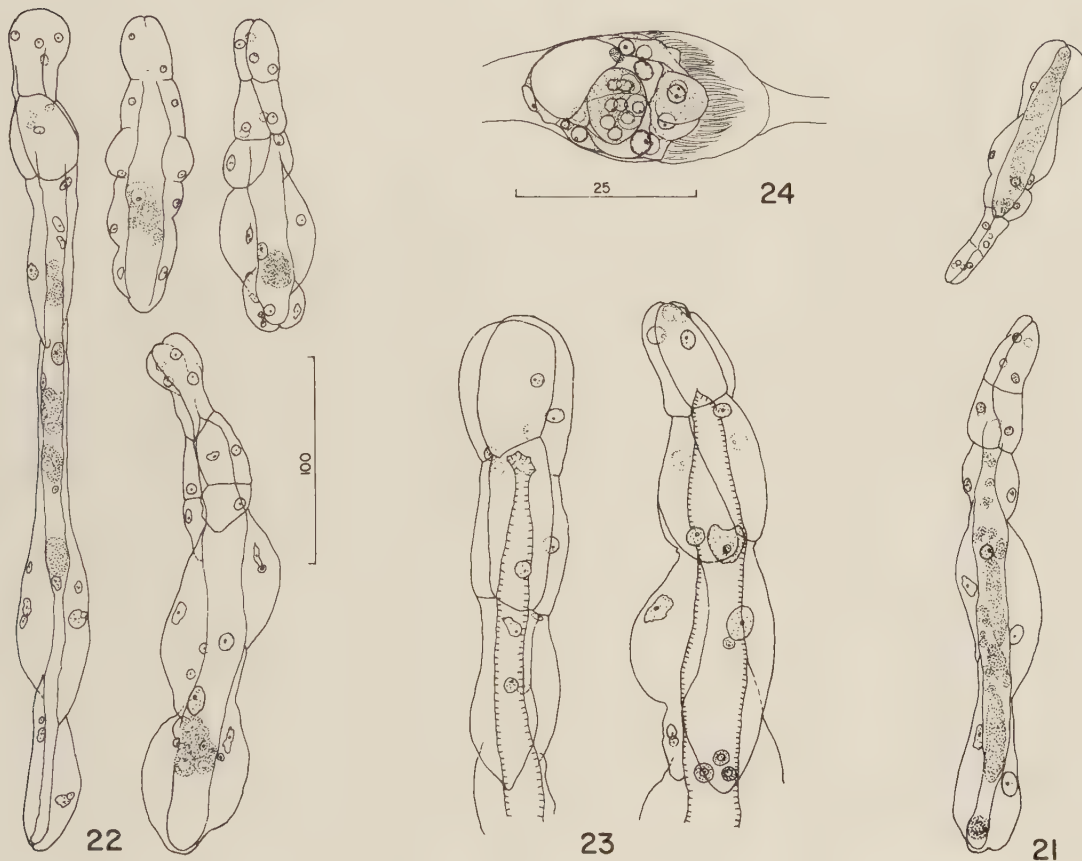


Figure 20

Dicyema briarei. Posterior ends of rhombogens showing variation in material in uropolar cells. From published photographs (Short 1961).

- 3(1) Somatic cells usually 14 4
- 3(1) Somatic cells usually 16 to 18 5
- 4(3) Lengths of mature nematogens 254 to 264 μm , mature rhombogens 438 to 657 μm . Somatic cell number almost invariably 14. Calotte markedly elongate; in young vermiform individuals often 30 to 50% of total length, in largest vermiforms 14 to 20% of total length. Parapolar cells usually shorter than calotte. Vermiform embryos about 40 to 50 μm long at eclosion. Refringent bodies, in infusoriforms viewed laterally, appearing larger than cluster of urn cells (see Fig. 3B)..... *D. hypercephalum* (Figs. 21-24)

Host: *Octopus joubini* Robson, 1929

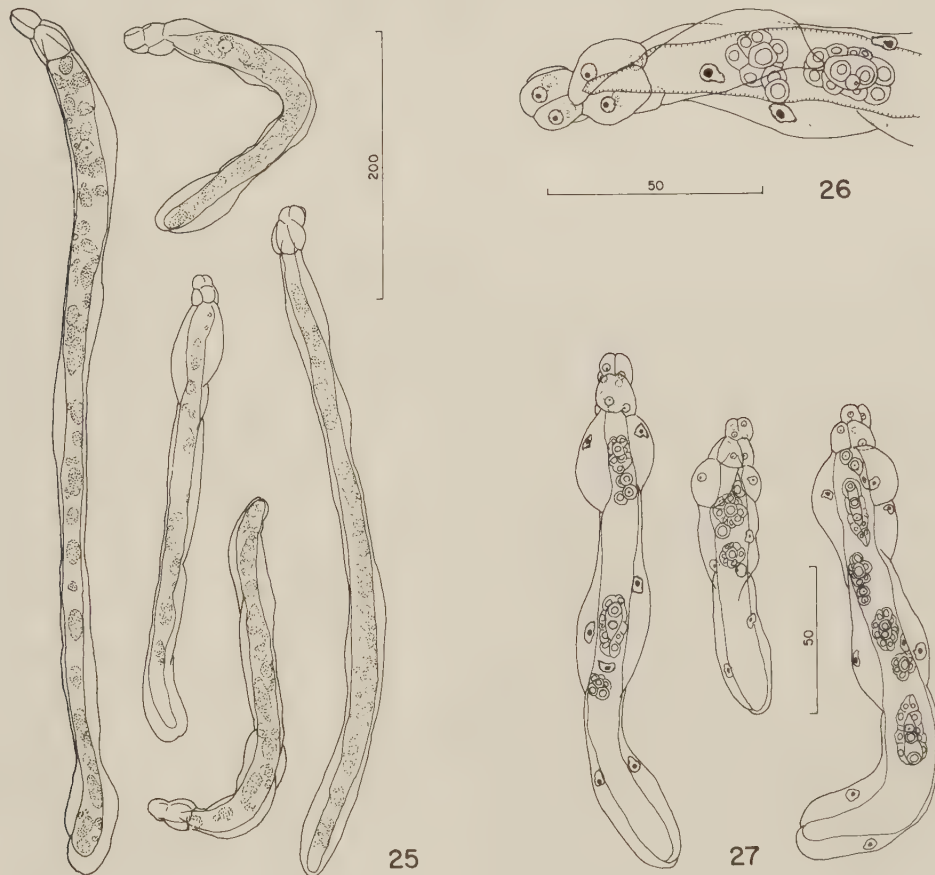


Figures 21-24

Dicyema hypercephalum. (21) Nematogens. (22) Rhombogens. (23) Anterior ends of rhombogens. (24) Infusoriform within axial cell of rhombogen, sagittal optical section. All figures from Short (1962). Scales in micrometers. Cilia not shown on vermiform stages.

- 4(3) Largest mature nematogens 299 to 645 μm long, seldom longer than 350 μm ; rhombogens unknown. Somatic cell numbers usually 14, sometimes 15, very occasionally otherwise. Calotte not markedly elongate; parapolar cells usually as long as or longer than calotte. Vermiform embryos about 20 to 25 μm long at eclosion (see Fig. 3C)..... *D. apalachiensis* (Figs. 25-27)

Host: *Octopus joubini* Robson, 1929

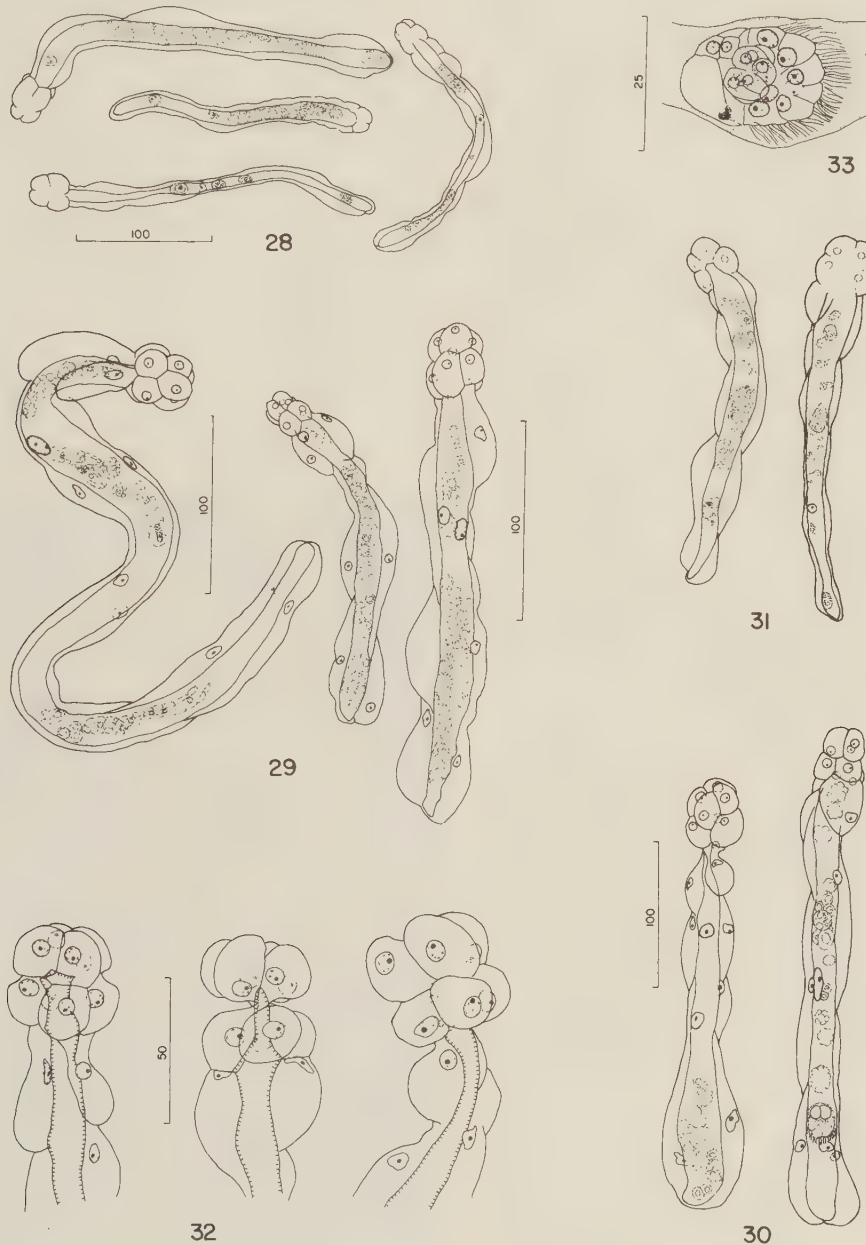


Figures 25-27

Dicyema apalachiensis. Nematogens. (26) Anterior end only. All redrawn from Short (1962). Scales in micrometers. Cilia not shown.

- 5(3) Largest nematogens 432 to 610 μm ; largest rhombogens 514 to 802 μm ; somatic cells 16 to 18, occasionally 15 or 19. Calotte large and conspicuous in older vermiform stages, appearing ellipsoidal to bilobed, often with a constriction between propolar and metapolar cells, anterior end of calotte in older vermiforms sometimes rather blunt with propolar region as broad as metapolar. Vermiform embryos 40 to 60 μm long at eclosion. Refringent bodies, in infusoriform viewed laterally, appearing about same size or only slightly larger than cluster of urn cells (see Fig. 4, A and B) *Dicyema bilobum* (Figs. 28–33)

Host: *Octopus vulgaris* Cuvier, 1797



Figures 28–33

Dicyema bilobum. (28 and 29) Nematogens. (30–32) Rhombogens. (32) Anterior ends only. (33) Infusoriform, optical sagittal section. All figures except 31 from Couch and Short (1964), mostly redrawn. Scales in micrometers. Cilia not shown on vermiform stages.

- 5(3) Largest nematogens 193 to 414 μm ; largest rhombogens 450-689 μm ; somatic cells almost always 18. Calotte relatively smaller than that of *D. bilobum* and with no tendency toward constriction between propolar and metapolar cells; often with cephalic swelling in parapolar region; in older rhombogens propolar and metapolar cells sometimes alternately arranged (in contrast to usual opposite arrangement in this and most other species of *Dicyema*). Vermiform embryos about 35 μm long at eclosion. Refrangent bodies of infusoriform appear considerably larger than the cluster of urn cells viewed laterally (see Fig. 3A). *Dicyema typoides* (Figs. 34-38)

Host: *Octopus vulgaris* Cuvier, 1797



Figures 34-38

Dicyema typoides. (34) Nematogens. (35) Anterior end of nematogen. (36) Rhombogens. (37) Infusoriforms in axial cell of rhombogens: (A) Frontal view; (B) Sagittal optical section. (38) Infusoriform side view. Urn cell stippled. Note unusually large refringent bodies. Except for (36), all from Short (1964). Scales in micrometers. Cilia not shown on vermiform stages.

Figure 39 (right)

Octopus vulgaris, ventral view. Dissected to show renal appendages (dotted outlines) within semitransparent renal sacs.



Annotated Systematic List

In addition to the six species in the genus *Dicyema* (family Dicyemidae) that have been reported from off the coasts of eastern North America and the Gulf of Mexico, Aldrich (1964) recorded a single dicyemid in a single specimen of the squid *Illex illecebrosus* from Newfoundland, and in 1989 I recovered an as yet unidentified species of *Dicyemeneea* from a specimen of *Bathypolypus arcticus* (furnished by Professor M.D.B. Burt) from off Grand Manan Island, south of St. Andrews, N.B., Canada.

As indicated above, the dicyemids are here considered to represent the phylum Dicyemida. In this system to my knowledge no class or order names have been assigned in the literature and it seems inappropriate to designate them in this manual. The species in this list are arranged alphabetically. Except for type host and locality, the locality and prevalence records summarize published and unpublished data (mostly from the present author's records). These records should not, of course, be interpreted as representing the true range of the parasites. It is my impression that octopods have not been examined systematically for dicyemids over most of the eastern and Gulf coasts of North America, and it is expected that at least some of the dicyemid species range much more widely than here indicated and that undescribed species remain to be discovered. Hochberg (E. Hochberg, Curator, Dept. of Invert. Zoology, Santa Barbara Mus. Nat. History, 2559 Puesta del Sol Rd., Santa Barbara, CA 93105, pers. commun., 1990) has pointed out that apparently unexamined potential octopod hosts in the region include *Octopus macropus*, *O. burryi*, *O. defilippi*, *O. carolinensis*, and *O. mercatoris*.

Family DICYEMIDAE E. van Beneden, 1882

Dicyema aegira McConnaughey and Kritzler, 1952—(Figs. 5B, 6, 10–16).

Stages Known—nematogen (primary), rhombogen, vermiform embryo, infusorigen, infusoriform larva.

Type Host and Locality—*Octopus vulgaris* Cuvier, 1797. Western North Atlantic Ocean, offshore from St. Augustine, Florida.

Additional Host—*Octopus joubini* Robson, 1929 (Short 1957).

Additional Localities—*Octopus vulgaris*, Western North Atlantic Ocean, coast of North Carolina, near Cape Lookout; Northern Gulf of Mexico, coast of Florida, Apalachee Bay west to Pensacola Bay. *Octopus joubini*, Northern Gulf of Mexico, coast of Florida, Apalachee Bay, near St. Teresa.

Prevalence (in *Octopus vulgaris*)—Of 26 hosts from the type locality examined, 25 were infected with dicyemids. The species of dicyemid was determined in 22. *Dicyema aegira* was in 17, 6 of which also harbored *D. typoides* (= *D. typus* of McConnaughey and Kritzler, 1952, see below).

Two hosts from the North Carolina coast near Cape Lookout were examined. Both were infected with *D. aegira*.

From the northern Gulf of Mexico off Florida, 147 hosts were examined; 144 were infected with dicyemids. The dicyemid species was determined in 122 hosts; *D. aegira* was present in 93, 18 of which also harbored *D. typoides*.

Prevalence (in *Octopus joubini*)—Four hosts from Apalachee Bay were examined; 2 harbored dicyemids that appeared to be *D. aegira*.

Other Reports—Austin (1964) reported on gametogenesis and Short and Damian (1966, 1967) on morphology of the infusoriform larva, oogenesis, fertilization, and first cleavage. Transmission electron microscopical studies were published by Ridley (1968, 1969).

Dicyema apalachiensis Short, 1962—(Figs. 3D, 25–27).

Stages Known—stem nematogen, nematogen (primary), vermiform embryo. The stem nematogen was described from an entire small specimen and part of a larger one.

Type Host and Locality—*Octopus joubini* Robson, 1929. Northern Gulf of Mexico, off Franklin Co., Florida, about 6 miles south of Light House Point.

Additional Hosts—none.

Additional Localities—none.

Prevalence—From the type locality, 13 hosts were examined; 12 were small, immature specimens, and all were infected with *D. apalachiensis*. One additional, larger specimen from the same locality was negative for *D. apalachiensis* but harbored *D. hypercephalum*.

Dicyema bilobum Couch and Short, 1964—(Figs. 4, A and B, 28–33).

Stages Known—nematogen (primary), rhombogen, vermiform embryo, infusorigen, infusoriform larva.

Type Host and Locality—*Octopus vulgaris* Cuvier, 1797. Northern Gulf of Mexico, off Pensacola Florida.

Additional Hosts—none.

Additional Localities—Northern Gulf of Mexico off Panama City, Florida.

Prevalence—Ten hosts from the type locality were examined; all were infected with dicyemids. In 2 hosts the species of parasites were not determined; of the remaining 8, 5 had *D. bilobum* alone and 3 *D. typoides* alone.

Other Report—Ridley (1968) reported transmission electron microscopical studies.

Dicyema briarei Short, 1961—(Figs. 5A, 7, 8, 17–20).

Stages Known—nematogen (primary), rhombogen, vermiform embryo, infusorigen, infusoriform larva.

Type Host and Locality—*Octopus briareus* Robson, 1929. Gulf of Mexico, inshore near Long Key, Florida Keys.

Additional Hosts—none.

Additional Localities—none.

Prevalence—Two of 16 adult octopuses from the type locality were infected in 1958. From 1959 to 1963, the following numbers of *O. briareus* from other locations were found not to be infected: 43 from areas in the Florida Keys; 12 from Bear Cut, Biscayne Bay, near Miami; and 3 from Bimini.

***Dicyma hypercephalum* Short, 1962**—(Figs. 3B, 21–24).

Stages Known—nematogen (primary), rhombogen, vermiform embryo, infusorigen, infusoriform larva.

Type Host and Locality—*Octopus joubini* Robson, 1929. Northern Gulf of Mexico, off Franklin Co., Florida, about 6 miles south of Light House Point.

Additional Hosts—none.

Additional Localities—Northern Gulf of Mexico, off Franklin Co., Florida, south of Dog Island.

Prevalence—From the type locality, 13 hosts were examined; 1 harbored *D. hypercephalum* alone, 12 had *D. apalachiensis*, and 7 of these also had an unidentified species of dicyemid.

From south of Dog Island, 2 hosts were examined; both were infected with *D. hypercephalum*.

***Dicyma typoides* Short, 1964**—(Figs. 3A, 34–38).

Stages Known—nematogen (primary), rhombogen, vermiform embryo, infusorigen, infusoriform larva.

Type Host and Locality—*Octopus vulgaris* Cuvier, 1797. Northern Gulf of Mexico, offshore about 3 miles from Panama City, Florida.

Additional Hosts—none.

Additional Localities—Northern Gulf of Mexico: Pensacola Bay; St. Joseph's Bay; Apalachee Bay—off Panacea, Alligator Point, Dog Island, St. George Island. Western Atlantic Ocean: offshore from St. Augustine, Florida; Bimini, Bahama Is., Bermuda Is.

Prevalence—From the northern gulf coast of Florida, 144 of 147 hosts were infected with dicyemids; of these 144, the species of dicyemid present was determined in 122 hosts. *Dicyma typoides* occurred in 48 hosts, 18 of which also harbored *D. aegira*.

From off St. Augustine, Florida, 12 of 13 hosts were infected; dicyemids were identified in 9; *D. typoides* occurred in 7, 3 of which also had *D. aegira*. McConnaughey and Kritzler (1952) reported *Dicyma typus* van Beneden, 1876, *sensu* Nouvel, 1946, from *Octopus vulgaris* offshore from St. Augustine, Florida. I believe that these authors were dealing with *D. typoides*, at that time (1952) not described. Four of 13 hosts were reported infected with "*D. typus*"; 3 of the 4 also had *D. aegira*.

Bimini. Of 24 hosts examined, 13 were parasitized by dicyemids; in 11 the species was determined; all harbored *D. typoides*.

Bermuda. Of 3 hosts examined, all harbored *D. typoides*.

Other reports—Ridley (1968, 1969) reported transmission electron microscopical studies of this species.

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Robert B. Short received the M.S. degree in biology from the University of Virginia in 1945 and the Ph.D. degree in zoology, with emphasis on parasitology, in 1950 from the University of Michigan. He was on the faculty of Florida State University from 1950 to 1990 and is now Professor Emeritus. His research interests have included the schistosomes as well as the dicyemid mesozoans.

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